VIII. *Magnetic Survey of Belgium in* 1871. *By the Rev.* Stephen J. Perry. *Communicated by General Sir* Edward Sabine, *F.R.S.*

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Previous to the year 1871 few observations had been made in Belgium for determining the elements of terrestrial magnetism, if we except the series which has been carried on without interruption at the Royal Observatory since 1828. Before this latter date the Intensity and Dip had never been ascertained, and there existed only two reliable measures of the Declination, viz. that of 20° 35′·5 for Ostend, which Pigot observed in 1772, and the other for Nieuport, which, at about the same date, was found by Mann to be 19° 48′·5. Since 1828 the observations made at any other station besides Brussels have not been numerous. In 1854 the Dip was measured at Antwerp, Courtray, Ghent, Mons, and Ostend; the Horizontal Force was found at Liége and Louvain in 1829, 1850, and 1854, and also at Namur in 1829; and the three elements were observed in 1859 at Ghent and Mechlin. The results of these various observations are collected in the work entitled "La Physique du Globe," by M. A. Quetelet, and in Dr. Lamont's 'Untersuchungen über die Richtung und Stärke des Erdmagnetismus in Belgien,' &c. The above being the only determinations of the magnetic elements, there is an obvious want of a complete series of observations at a sufficient number of stations, and the survey which forms the subject of the present paper was undertaken with the view of supplying the required series of connected values of the three elements.

The instruments employed in this survey were the Barrow dip-circle, the Jones unifilar, and the Frodsham chronometer of Stonyhurst Observatory, and an excellent theodolite by Troughton and Simms for determining the azimuth of the fixed points for the Declination. For this last instrument I was indebted to the kindness of James Shoolbred, Esq., C.E. All necessary information respecting the magnets and instruments will be found in the paper on the Magnetic Survey of the West of France printed in the Phil. Trans. of 1870.

The methods of observation and reduction were identical with those adopted in the preceding surveys.

At all the stations in Belgium the Dip was observed by Mr. W. Carlisle, the readings for each needle being never less than 32; the remaining elements were determined by myself.

In forming the equations of condition for the determination of the lines of equal Dip, Declination, and Intensity, the Royal Observatory of Brussels has been chosen as the origin of coordinates.

TABLE I.

Station.	Latitude.	Longitude.	Difference in miles of		Place of observation.
			Lat.	Long.	
	° ′ ″	m s			
Aix-la Chapelle	50 46 0	6 51	− 6·0	+75·1	18 Aurelius Strasse.
Alost	50 56 18	1 19	+ 5·9	−14·4	Garden of the College.
Antwerp	51 13 15	0 8	+25·4	+ 1·4	Courte rue Neuve.
Arlon	49 41 0	5 39	−80·8	+63·6	Rue du Luxembourg 46.
Bruges	51 12 30	4 35	+24·6	−49·8	Rue Flamande 60.
Brussels	50 51 11	0 0	0·0	0·0	Royal Observatory, 131 rue Royale.
Courtray	50 49 0	4 21	− 2·5	−47·6	Garden near Church of St. Michael.
Ghent	51 3 12	2 34	+13·8	−28·0	Rue d'Assaut 26.
Liége	50 39 0	4 51	−14·0	+53·4	Collége St. Servais.
Lierre	51 7 0	0 47	+18·2	+ 8·5	Vineyard close by Parish Church.
Louvain	50 53 27	1 19	+ 2·6	+14·3	Rue des Récollets 11.
Mechlin	51 1 45	0 26	+12·2	+ 4·7	Boulevards des Arbalétriers 83.
Mons	50 27 0	1 41	−27·9	−18·6	Collége St. Stanislas.
Namur	50 28 2	1 56	−26·7	+21·3	Collége N. D. de la Paix.
Ostend	51 13 47	5 48	+26·0	−63·0	Garden near the Church.
Spa	50 29 0	5 55	−25·5	+65·2	Rue de Wauxhall 43.
Tournay	50 36 22	3 55	−17·1	−43·1	Collége Notre Dame.
Tronchiennes	51 3 12	2 49	+13·8	−30·8	Ancienne Abbaye.
Turnhout	51 19 0	2 11	+32·1	+23·7	Collége St. Joseph.
Verviers	50 36 0	5 55	−17·5	+65·1	Collége St. François Xavier.

A comparison of the large atlases of FERRARIS, PHILIP, and the Useful Knowledge Society have supplied the required data for the above geographical latitudes and longitudes, whenever these could not be obtained directly from the 'Connaissance des Temps.'

The Magnetic Dip.

As this element has been observed almost invariably with each of the three needles employed throughout the survey, any very accurate comparison of the readings obtained with the several needles is thus rendered unnecessary. It may suffice to remark that needles Nos. 2 & 3 give mean results which are scarcely perceptibly at variance, whilst the readings of No. 1 are about 1′·5 in excess of the mean of the other two.

TABLE II.

Station.	Date.	G.M.T.	Dip.			
			Needle No. 1.	Needle No. 2.	Needle No. 3.	Mean.
	1871.	h m				
Antwerp	Aug. 5	9 5 A.M.	67° 4′ 29″			
		10 50 „	.....	67° 0′ 8″		
		3 15 P.M.	.....	.....	66° 59′ 19″	67° 1′ 19″
Brussels, 131 rue Royale	„ 8	10 15 A.M.	67 5 57			
		3 15 P.M.	.....	67 12 34		
		4 50 „	.....	.....	67 8 50	67 9 7
Brussels Observatory	„ 9	10 50 A.M.	66 56 34			
		12 15 P.M.	.....	67 1 34	.....	66 59 4
Louvain	„ 11	10 10 A.M.	66 58 12			
		2 55 P.M.	.....	66 54 11		
		4 55 „	.....	.....	66 53 38	66 55 12
Mechlin	„ 14	8 10 A.M.	66 47 39			
		9 55 „	.....	66 40 36	.....	66 44 8
Lierre	„ 14	4 0 P.M.	66 59 30			
	„ 15	8 5 A.M.	.....	66 54 47		
		9 55 „	.....	.....	67 0 19	66 58 12
Turnhout	„ 16	10 20 „	67 10 6			
		4 15 P.M.	.....	67 6 2		
		5 44 „	.....	.....	67 7 56	67 8 1

TABLE II. (continued).

Station.	Date.	G.M.T.	Dip.			
			Needle No. 1.	Needle No. 2.	Needle No. 3.	Mean.
	1871.	h m				
Verviers	Aug. 23	8 40 A.M.	66° 47′ 8″			
		10 15 „	.....	66° 40′ 55″		
		11 35 „	.....	.....	66° 44′ 49″	66° 44′ 17″
Liége	„ 25	7 45 „	66 29 47			
		2 50 P.M.	.....	66 28 28		
	„ 26	9 35 A.M.	.....	.....	66 28 45	66 29 0
Aix-la-Chapelle	„ 26	4 30 P.M.	66 38 17			
		5 45 „	.....	66 43 49		
	„ 28	9 10 A.M.	.....	.....	66 36 8	66 39 25
Spa	„ 29	8 10 „	66 40 34			
		9 30 „	.....	66 41 11		
		11 0 „	.....	.....	66 39 15	66 40 20
Arlon	„ 31	8 45 „	65 56 23			
		10 10 „	.....	65 55 17		
		11 10 „	.....	.....	65 55 4	65 55 35
Namur	Sept. 2.	8 40 „	66 35 34			
		9 40 „	.....	66 29 19		
		10 50 „	.....	.....	66 35 21	66 33 25
Mons	„ 4.	2 45 P.M.	66 33 29			
		3 50 „	.....	66 38 39		
		4 50 „	.....	.....	66 34 20	66 35 29
Tournay	„ 6.	3 10 „	66 42 15			
		4 20 „	.....	66 38 34		
		5 25 „	.....	.....	66 36 4	66 38 58
Courtray	„ 7.	3 30 „	66 41 25			
		4 35 „	.....	66 38 19		
	„ 8.	7 45 A.M.	.....	.....	66 45 38	66 41 47
Ghent	„ 8.	3 20 P.M.	67 13 34			
	„ 10.	8 0 A.M.	.....	67 14 12		
		9 18 „	.....	.....	67 15 15	67 14 20
Ostend	„ 11.	4 35 P.M.	67 14 20			
		5 25 „	.....	67 16 26		
	„ 12.	4 15 „	.....	.....	67 10 19	67 13 42
Bruges	„ 13.	9 16 A.M.	67 14 35			
		11 10 „	.....	.....	67 7 21	
	„ 14.	4 40 P.M.	.....	67 9 4	.....	67 10 20
Tronchiennes	„ 15.	3 30 „	67 21 35			
		4 30 „	.....	67 22 35		
	„ 16.	8 55 A.M.	.....	.....	67 23 47	67 22 39
Alost	„ 18.	3 14 P.M.	67 15 28			
		4 15 „	.....	67 11 12		
	„ 19.	9 34 A.M.	.....	.....	67 14 0	67 13 33
Brussels, 131 rue Royale	„ 20.	4 50 P.M.	67 9 8			
	„ 23.	8 35 A.M.	.....	67 6 39		
	„ 25.	7 45 „	.....	.....	67 2 51	67 6 13
Brussels Observatory	„ 22.	10 35 „	67 1 21			
		2 0 P.M.	.....	66 58 12		
		3 5 „	.....	.....	67 1 2	67 0 12

Expressing the mean values in decimals of a degree, and subtracting 65° from each, we obtain the equations required for determining the distance apart, and the inclination to the meridian, of the lines of equal Dip.

$$1{\cdot}657 = \delta - 75{\cdot}1x - 6{\cdot}0y$$
$$2{\cdot}226 = \delta + 14{\cdot}4x + 5{\cdot}9y$$
$$2{\cdot}022 = \delta - 1{\cdot}4x + 25{\cdot}4y$$
$$0{\cdot}926 = \delta - 63{\cdot}6x - 80{\cdot}8y$$
$$2{\cdot}172 = \delta + 49{\cdot}8x + 24{\cdot}6y$$
$$1{\cdot}696 = \delta + 47{\cdot}6x - 2{\cdot}5y$$
$$2{\cdot}239 = \delta + 28{\cdot}0x + 13{\cdot}8y$$

$$1{\cdot}484=\delta-53{\cdot}4x-14{\cdot}0y$$
$$1{\cdot}970=\delta-\ 8{\cdot}5x+18{\cdot}2y$$
$$1{\cdot}920=\delta-14{\cdot}3x+\ 2{\cdot}6y$$
$$1{\cdot}736=\delta-\ 4{\cdot}7x+12{\cdot}2y$$
$$1{\cdot}591=\delta+18{\cdot}6x-27{\cdot}9y$$
$$1{\cdot}557=\delta-21{\cdot}3x-26{\cdot}7y$$
$$2{\cdot}228=\delta+63{\cdot}0x+26{\cdot}0y$$
$$1{\cdot}672=\delta-65{\cdot}2x-25{\cdot}5y$$
$$1{\cdot}650=\delta+43{\cdot}1x-17{\cdot}1y$$
$$2{\cdot}378=\delta+30{\cdot}8x+13{\cdot}8y$$
$$2{\cdot}134=\delta-23{\cdot}7x+32{\cdot}1y$$
$$1{\cdot}738=\delta-65{\cdot}1x-17{\cdot}5y$$

The solution of these equations of condition, found by the method of least squares, is $\delta=1{\cdot}87299$, $x=0{\cdot}0013762$, $y=-0{\cdot}0104147$.

The computed value of the Dip at the central station is therefore 66°·87299, the direction of the Isoclinals being from N. 82° 28′ 19″·4 E. to S. 82° 28′ 19″·4 W., and the distance between stations, whose Dips differ by 0°·5, 47·6 miles.

The Dip at the several stations obtained from this calculated data, and compared with the observed mean values, furnishes the following Table of errors:—

TABLE III.

Station.	Observed Dip.	Computed Dip.	Errors.
Aix-la-Chapelle	1·657	1·708	−0·051
Alost	2·226	1·954	+0·272
Antwerp	2·022	2·136	−0·114
Arlon	0·926	0·943	−0·017
Bruges	2·172	2·198	−0·026
Courtray	1·696	1·912	−0·216
Ghent	2·239	2·056	+0·183
Liége	1·484	1·654	−0·170
Lierre	1·970	2·051	−0·081
Louvain	1·920	1·880	+0·040
Mechlin	1·736	1·994	−0·258
Mons	1·591	1·608	−0·017
Namur	1·557	1·566	−0·009
Ostend	2·228	2·229	−0·001
Spa	1·672	1·517	+0·155
Tournay	1·650	1·754	−0·104
Tronchiennes	2·378	2·059	+0·319
Turnhout	2·134	2·174	−0·040
Verviers	1·738	1·601	+0·137

The probable error at any one station will therefore be $\pm 0{\cdot}10445$, whilst that of the mean Dip at the central station is $\pm 0{\cdot}02185$.

Referring now to previous observations, we shall be able to ascertain approximately the secular variation of the Dip. The only determinations of this magnetic element for stations out of Brussels are those of M. MAHMOUD EFFENDI in 1854 and of Dr. LAMONT in 1858, and these will serve to form the following Tables.

TABLE IV.

Station.	Dip, 1854.	Dip, 1871.	Diff. of Epoch.	Diff. of Dip.	Yearly rate.
Antwerp.....	67°·875	67°·022	17	−0·853	−0·050
Courtray	67·655	66·696	,,	−0·959	−0·056
Ghent.....	67·833	67·239	,,	−0·594	−0·036
Mons	67·383	66·591	,,	−0·792	−0·047
Ostend	68·047	67·228	,,	−0 819	−0·048
Brussels	67·663	66·994	,,	−0·669	−0·039
				Mean for 1862·5...	−0·046

TABLE V.

Station.	Dip, Jan. 1, 1858.	Dip, Sept. 1, 1871.	Diff. of Epoch.	Diff. of Dip.	Yearly rate.
Aix-la-Chapelle.....	67°·445	66°·657	13¾	−0·788	−0·058
Ghent.....	68·002	67·239	,,	−0·763	−0·056
Mechlin	67·643	66·736	,,	−0·907	−0·066
Brussels	67·663	66·994	,,	−0·669	−0·049
				Mean for 1864·8...	−0·0573

The values for Ghent and Brussels in the first column of figures of Table IV. do not inspire much confidence, as the latter is identical with LAMONT'S value for 1858; and the former is much smaller than the corresponding number in Table V., although observed four years previously.

Table V. gives a secular variation which lies about midway between the values −0·062 and −0·054 found respectively for the West and East of France. Table IV. would make the secular variation −0·050, if we neglected the two doubtful quantities.

Dr. LAMONT gives −0·0417 as the annual decrease for 1858, which would indicate an acceleration of the yearly rate. We know, however, from the continuous series of observations made at the Brussels Observatory, and published in its 'Annuaire' by the eminent Director, M. A. QUETELET, that the annual decrease has been gradually diminishing from 0°·0527 in 1830 to 0°·0194 in 1865, the yearly variation being 0·00095. The extreme values of the Dip observed at the Royal Observatory at Brussels were 68° 56′·5 in 1827·8, and 67° 8′·0 in 1871·5.

The Magnetic Intensity.

TABLE VI.

Station.	Date.	G.M.T.	Distance of centres of magnets.	Temp.	Observed deflection.	Log $\frac{m}{X}$.	Date.	G.M.T.	Temp.	Time of one vibration.	Log mX.
	1871.							h m s			
Antwerp	Aug. 5	4 3 P.M.	1·0	67°·1	13° 26′ 52″	9·06882	Aug. 5	1 56 11 P.M	75°·5	5·371295	0·25704
		4 26	1·3	65·8	6 5 33	9·06927					
Brussels Observatory.	„ 9	11 2 A.M.	1·0	76·9	13 20 52	9·06638	„ 9	12 42 6	81·1	5·35230	0·26039
		11 28	1·3	77·8	6 1 51	9·06578		12 51 56	81·5	5·35120	0·26060
Brussels, 131 rue Royale.	„ 10	4 36 P.M.	1·0	78·0	13 26 58	9·06970	„ 10	7 25 11 A.M.	70·6	5·37560	0·25591
								8 12 50	72·3	5·376085	0·25595
								8 23 47	74·0	5·37571	0·25613
Louvain	„ 11	10 43 A.M.	1·0	78·9	13 20 18	9·06624	„ 11	3 34 42 P.M.	80·4	5·349085	0·26084
		11 14	1·3	79·7	6 2 31	9·06674		3 43 37	80·3	5·34900	0·26085
							„ 12	.....	76·8	5·35183	0·26011
								8 32 24 A.M.	76·5	5·353795	0·25978
Turnhout	„ 16	4 58 P.M.	1·0	74·8	13 21 4	9·06633	„ 17	8 26 46	76·7	5·35285	0·25997
		5 26	1·3	73·5	6 3 9	9·06701		8 36 12	81·2	5·35436	0·26004
Liége	„ 24	11 6 A.M.	1·0	72·4	13 8 42	9·05950	„ 24	9 31 46	71·3	5·31033	0·26656
		11 31	1·3	71 6	5 57 12	9·05972			71·5	5·31292	0·26615
Aix-la-Chapelle	„ 28	9 25	1·0	62·9	13 12 15	9·06073	„ 28	7 46 4	62·8	5·309335	0·26604
		9 49	1·3	63·0	5 58 27	9·06059		7 55 55	62·8	5·31196	0·26561
Spa	„ 29	9 40	1·0	66·1	13 6 17	9·05773	„ 29	8 3 54	63·1	5·30525	0·26667
		10 6	1·3	66·7	5 57 0	9·05911		8 12 45	62·7	5·30567	0·26657
Arlon	„ 31	4 5 P.M.	1·0	71·9	12 48 10	9·04820	„ 31	10 36 13	77·7	5·24971	0·27710
		4 34	1·3	70·2	5 48 1	9·04832		10 45 33	75·2	5·24888	0·27706
Namur	Sept. 2	8 28 A.M.	1·0	73·9	13 13 12	9·06205	Sept. 2	9 34 44	80·1	5·32917	0·26418
		8 56	1·3	75·1	5 58 50	9·06196			81·1	5·325875	0·26479
Mons	„ 4	2 41 P.M.	1·0	78·0	13 7 32	9·05929	„ 5	7 54 21	66·4	5·321795	0·26427
	„ 5	9 44 A.M.	1·0	67·2	13 8 54	9·05922			66·2	5·32092	0·26443
		10 8	1·3	67·7	5 56 54	9·05906		8 24 10	67·4	5·32263	0·26428
									67·5	5·32108	0·26454
Tournay	„ 6	3 58 P.M.	1·0	81·5	13 8 29	9·06009	„ 6	5 3 40 P.M.	78·4	5·334665	0·26303
		4 23	1·3	81·0	5 56 59	9·06017		5 25 35	77·6	5·332125	0·26340
								5 33 27	77·0	5·33175	0·26342
Courtray	„ 8	8 16 A.M.	1·0	66·2	13 11 34	9·06059	„ 7	3 23 43	71·2	5·32100	0·26483
		8 38	1·3	66·1	5 58 12	9·06052		3 32 35	71·0	5·319665	0·26505
Ghent	„ 9	4 10 P.M.	1·0	67·0	13 26 35	9·06866	„ 9	2 44 46	71·6	5·38500	0·25463
		4 37	1·3	65·9	6 5 5	9·06874		2 53 44	70·1	5·38271	0·25490
Ostend	„ 11	5 55	1·0	69·1	13 27 30	9·06931	„ 11	4 42 40	70·2	5·38850	0·25395
	„ 12	10 22 A.M.	1·0	67·8	13 27 8	9·06901		4 51 38	70·1	5·38596	0·25436
		10 45	1·3	67·6	6 5 12	9·06900					
Bruges	„ 13	8 52	1·0	63·2	13 23 43	9·06687	„ 13	10 11 34 A.M.	67·2	5·369495	0·25665
		9 16	1·3	63·5	6 3 54	9·06715		10 20 31	68·2	5·36480	0·25748
							„ 14	4 15 8 P.M,	63·1	5·35975	0·25786
								4 24 3	62·5	5·358125	0·25808
Tronchiennes	„ 17	9 0	1·0	57·3	13 31 30	9·07055	„ 16	10 37 5 A.M.	71·7	5·39492	0·25299
		9 26	1·3	57·9	6 7 2	9·07046		10 46 5	70·3	5·391335	0·25346
							„ 17	10 6 4	61·1	5·39083	0·25279
								10 15 3	61·9	5·39064	0·25286
Alost	„ 18	3 4 P.M.	1·0	58·8	13 20 49	9·06500	„ 18	4 8 3 P.M.	59·8	5·356335	0·25822
		3 28	1·3	58·1	6 2 37	9·06523		4 15 28	59·2	5·35571	0·25829
Brussels Observatory.	„ 22	2 16	1·0	59·7	13 17 13	9·06315	„ 22	3 30 16	60·4	5·34995	0·25945
		2 41	1·3	60·3	6 1 4	9·06353		4 25 34	57·4	5·34281	0·26039
Brussels, 131 rue Royale.	„ 23	9 38 A.M.	1·0	56·0	13 27 53	9·06856	„ 23	11 1 57 A.M.	62·2	5·37873	0·25485
		10 7	1·3	57·1	6 5 26	9·06852					

This Table, combined with the preceding determinations of the Dip, furnishes us with the means of calculating the components of the earth's magnetic intensity, and the magnetic moment of the vibration-needle.

TABLE VII.

Station.	H. F.	V. F.	T. F.	*m*.
Aix-la-Chapelle	4·0045	9·2792	10·1064	0·46052
Alost	3·9503	9·4054	10·2049	0·45887
Antwerp	3·9274	9·2623	10·0606	0·46031
Arlon	4·1157	9·2121	10·0896	0·45991
Bruges	3·8934	9·2495	10·0355	0·45949
Brussels Observatory	3·9595	9·3252	10·1310	0·45956
Brussels, rue Royale	3·9189	9·2899	10·0827	0·45948
Courtray	4·0011	9·2889	10.1139	0·45999
Ghent	3·9180	9·3382	10·1268	0·45892
Liége	4·0126	9·2211	10·0563	0·46024
Louvain	3·9544	9·2799	10·0873	0·46073
Mons	4·0048	9·2507	10·0804	0·45897
Namur	3·9923	9·2066	10·0349	0·46052
Ostend	3·9136	9·3226	10·1112	0·45881
Spa	4·0221	9·3267	10·1570	0·45976
Tournay	3·9958	9·2556	10·0813	0·45889
Tronchiennes	3·9016	9·3626	10·1430	0·45896
Turnhout	3·9522	9·3715	10·1708	0·46062

The second members of our original equations remaining each unchanged, but being three fewer in number, Table VII. will enable us at once to form the equations of condition for determining the nature of the lines of equal Horizontal Force. Their solution leads to the following values: H. F.$=3{\cdot}96649$, $x=-0{\cdot}00030302$, $y=0{\cdot}0015808$.

Hence we find that there is a distance of 62·13 miles between the lines, indicating a difference of 0·1 in the Horizontal Force, and that this system of lines is inclined at an angle of 79° 8′ 55″·7 to the meridian, the direction being from N. 79° 8′ 55″·7 E. to S. 79° 8′ 55″·7 W. The differences between the observed results and those computed from the above data furnish a Table for calculating the probable errors.

TABLE VIII.

Station.	Observed.	Computed.	Obs.−Comp.
Aix-la-Chapelle	4·0045	3·9988	+0·0057
Alost	3·9503	3·9529	−0·0026
Antwerp	3·9274	3·9268	+0·0006
Arlon	4·1157	4·1138	+0·0019
Bruges	3·8934	3·9126	−0·0192
Courtray	4·0011	3·9562	+0·0449
Ghent	3·9180	3·9363	−0·0183
Liége	4·0126	4·0050	+0·0076
Louvain	3·9544	3·9668	−0·0124
Mons	4·0048	4·0052	−0·0004
Namur	3·9923	4·0153	−0·0230
Ostend	3·9136	3·9064	+0·0072
Spa	4·0221	4·0267	−0·0046
Tournay	3·9958	3·9807	+0·0151
Tronchiennes	3·9016	3·9355	−0·0339
Turnhout	3·9522	3·9230	+0·0292

This gives us as the probable error for the mean at a single station $\pm 0{\cdot}01327$, whilst that at the central station is $\pm 0{\cdot}00332$.

In order to determine the secular change of the Horizontal Intensity, I have collected together, and reduced to English units, all the previous observations with which I am acquainted. The values for 1858 are taken from Dr. LAMONT'S 'Erdmagnetismus,' and those for 1839 and 1854 may be found scattered in the introduction to the same work.

The numbers for 1829 and 1850 have been calculated from the data given in M. A QUETELET's treatise 'Sur la Physique du Globe;' and for 1850 I have made the supposition, which I find to be most consonant with the observations cited in the same work, that the ratio between the values of Horizontal Force at Paris and Brussels is on the whole nearly constant, that ratio being 0·961.

TABLE IX.

	1829.	1839.	1850.	1854.	1858.
Aix-la-Chapelle.....	3·7661	3·8357	3·8796	3·9138	3·9349
Antwerp.....	.....	.....	.....	3·8570	.....
Ghent.....	.....	.....	.....	3·8208	3·8553
Liége	3·7984	3·8316	3·8755	3·8971	.....
Louvain.....	3·7355	[3·8375]	[3·8835]	3·8730	.....
Mechlin.....	.....	.....	.....	.....	3·9077
Namur	3·8208	.....	.....	.....	.....
Ostend	.....	.....	.....	3·8056	.....

Neglecting the two observations enclosed within brackets as being evidently too large, we find, by comparing these numbers with those given in Table VIII., the following values of the secular variation:—

TABLE X.

Epoch.....	1850.	1855.	1860·5.	1862·5.	1864·8.
Secular variation . .	0·00502	0·00547	0·00624	0·00552	0·00484

These results give +0·00542 as the mean value of the yearly change of the Horizontal Force for the epoch 1858·56. If we compare this with the annual increase deduced from the numerous observations made at Brussels between the years 1828 and 1860, we obtain a strong confirmation of the approximate correctness of the above value. HANSTEEN, LAMONT, and QUETELET have each expressed the law of increase of the Horizontal Force at Brussels in an analytical form, and these formulæ give respectively, for the epoch 1850, 0·005422, 0·005183, and 0·005617, as the secular increase. The mean of these differs from the result found above only by 0·000031. The acceleration for the same date given by HANSTEEN's formula is +0·000037; but QUETELET makes the increase of the yearly rate considerably more rapid. The concluded value of the secular variation of the Horizontal Force for Belgium is slightly in excess of that found for France from the surveys of 1868 and 1869.

We will now pass on to the discussion of the results obtained from the combined observations of the Dip and Horizontal Force at the several stations. Instead of forming new equations of condition with the values given in Table VII., and then solving them by the method of least squares, we can find the Intensity at each station by combining directly the computed as well as the observed values in Tables III. and VIII., and thence deduce the probable errors. Calling the Intensity deduced immediately from the observed Horizontal Force and Dip the observed Intensity, and that formed from the computed values the computed Intensity, we thus obtain the following results:—

TABLE XI.

Station.	Observed T. F.	Computed T. F.	Observed – Computed.
Aix-la-Chapelle	10·1064	10·1129	−0·0065
Alost	10·2049	10·0976	+0·1073
Antwerp	10·0606	10·1064	−0·0458
Arlon	10·0896	10·0917	−0·0021
Bruges	10·0355	10·0958	−0·0603
Courtray	10·1139	10·0886	+0·0253
Ghent	10·1268	10·0974	+0·0294
Liége	10·0563	10·1064	−0·0501
Louvain	10·0873	10·1024	−0·0151
Mons	10·0804	10·0882	−0·0078
Namur	10·0349	10·0965	−0·0616
Ostend	10·1112	10·0927	+0·0185
Spa	10·1570	10·1052	+0·0518
Tournay	10·0813	10·0859	−0·0046
Tronchiennes	10·1430	10·0966	+0·0464
Turnhout	10·1708	10·1125	+0·0583

The probable error at any station would thus be $\pm 0{\cdot}0321$, whilst that of the mean is $\pm 0{\cdot}0080$.

If we examine carefully the above figures, we find that the intensity increases as we proceed Northwards, but that the computed and observed values do not agree as to the Eastward or Westward tendency of the lines. The observed values in the West are greater than those in the East; but when the distance of each station from the meridian of Brussels is taken into account, the isodynamics are found to lie N.W. and S.E. This result is confirmed by combining the observed values by the method of least squares, which gives 10·10525 as the Total Force at the central station, and for the direction of the lines N. 70° 3′ 34″·6 W. to S. 70° 3′ 34″·6 E. That this is not caused by mere accidental errors at certain stations may be clearly shown; for, casting out those stations whose values are abnormal, and then recalculating the position of the lines of equal Intensity, we obtain a very similar result, even when as many as the six least reliable values are omitted. It is unfortunate that LAMONT'S survey of 1858 does not afford sufficient data for computing the isodynamics in Belgium alone for that epoch; but if we take his stations in Belgium and Holland, along with the neighbouring positions of Aix-la-Chapelle and Emden, we obtain nine equations of condition, which furnish lines of equal Intensity common to the two countries, and the direction of these is from N. 57° 6′ 6″·3 E. to S. 57° 6′ 6″·3 W. The probable errors are very nearly the same as those given above, being $\pm 0{\cdot}031582$ for a single station and $\pm 0{\cdot}010527$ for the mean. Of the three stations common to the two surveys the error for Aix-la-Chapelle is positive, whilst those of Ghent and Mechlin are negative. We have therefore indications of the existence of some great disturbing cause, which, by increasing the intensity at the eastern stations, tends to alter the direction of the isodynamics, and to remove further apart the lines passing through points whose Total Force differs by a constant quantity. A centre of local magnetic force may therefore not unnaturally be sought for in the eastern portion of Belgium, and the geological map of the country presents at once a ready answer to the inquiry. Starting from the neighbourhood of Mons, the vast coal tracks of Belgium, rich in iron ore, stretch across the eastern provinces, enveloping

Namur, Liége, and Aix-la-Chapelle, whilst the remainder of the country appears to be wholly devoid of all ferruginous wealth.

As a further series of observations in this region might throw considerable light on the subject of local magnetism, I purpose, unless the work is previously undertaken by others, again to observe the magnetic elements at closer stations within this interesting area.

If the disturbing cause is unchangeable, it will probably not interfere much with the determination of the secular variation of the Intensity as given in the annexed Table.

TABLE XII.

Station.	T. F., Jan. 1, 1858.	T. F., Sept. 1, 1871.	Diff. of Epoch.	Yearly change.
Aix-la-Chapelle.....	10·2586	10·1064	$13\frac{2}{3}$	−0·01114
Ghent.....	10·2923	10·1268	,,	−0·01211
Brussels.....	10·2869	10·1310	,,	−0·01141
			Mean for 1864·8...	−0·01155

The Magnetic Declination.

In the observations for determining this element the azimuth of the fixed mark was found by taking transits of the sun with a transit-theodolite by SIMMS, kindly placed at my disposal for this survey by J. SHOOLBRED, Esq., C.E.; and the angular distance between the mark and the magnetic meridian was read on JONES's unifilar. The same tripod served for both instruments. Before observing the sun, the fixed mark was bisected by the wire of the telescope, when the verniers of the azimuth-circle read 0° and 180°; thus the figures in the 6th column of Table XIV. are either the means of the readings as taken, or their defect from 360°.

The same magnet was used for all the observations, and each entry is the mean of the readings with erect and inverted scale. The scale-coefficient is 2′ 9″·805. For the observations at the Royal Observatory, Brussels, on the 9th of August, the zero-mark was not determined by observed transits with the theodolite, but a plumb-line was suspended in the meridian in front of the magnetic hut by aid of the large transit instrument of the observatory, and then the unifilar was adjusted in the meridian as accurately as this method would permit. The chronometer used was FRODSHAM'S No. 3148. The following Table contains the results of the comparisons made at Brussels and Stonyhurst:—

TABLE XIII.

Station.	Date.	G. M. T.	Error.	Daily Rate.
	1871.	h m	m s	
Stonyhurst Observatory	July 31	7 30 P.M.	+28 44·62	+3·09
Brussels Observatory	Aug. 9	7 30 ,,	+29 15·10	+3·39
,, ,, ...	Sept. 22	7 30 ,,	+32 21·90	+4·25
Stonyhurst.....	,, 29	11 0 ,,	+32 45·01	+3·24
,, ...	Oct. 3	10 0 ,,	+32 55·69	+2·69

For the comparisons at the Brussels Observatory I am indebted to the kindness of M. E. QUETELET.

It was not possible to compare the chronometer oftener; but this is less to be regretted, as the behaviour of the instrument during the French surveys showed that it is not liable to any great change of rate whilst travelling, if carried always with care. As it was previously found that the rate of the chronometer could be more securely trusted than the deduced rates from observed altitudes of the sun, the latter were not observed in Belgium.

TABLE XIV.

Station.	Date.	Chronometer.	Error at Noon.	Daily Rate.	Azimuthal distance of sun from mark.	Azimuthal reading of magnet.	Azimuthal reading of mark.
	1871.	h m s	m s	s	° ′ ″		
Antwerp	Aug. 5	10 2 14·5 A.M.	+29 0·49	+3·39	44 47 30		
		10 18 4·1	.....	.....	39 52 15		
		10 42 9	.....	.....	.....	244 54 37·0	
		10 49 5	.....	.....	.....	244 54 56·5	256 35 30
Brussels Observatory	„ 9	4 3 30 P.M.	29 14·04				
		4 20					
Brussels, 131 rue Royale	„ 10	8 14 42·8 A.M.	29 18·02	+4·245	47 34 0		
		8 22 0·9	.....	.....	45 59 30		
		9 25	.....	.....	.....	171 19 42·35	
		9 30	.....	.....	.....	171 19 42·35	159 11 40
Louvain	„ 11	10 1 57·1	29 22·26	.....	53 36 0		
		10 11 23·6	.....	.....	50 42 45		
		8 44 0	.....	.....	.....	199 10 10·0	
		8 49 30	.....	.....	.....	199 8 58·2	
		8 56 30	.....	.....	.....	199 6 35·4	220 16 6·7
Turnhout	„ 16	10 56 31·4	29 43·49	.....	145 43 45		
		11 9 14·3	.....	.....	150 18 30		
		11 28 52·8	.....	.....	157 38 45		
		11 34 39·8	.....	.....	159 52 10		
		12 10 5 P.M.	.....	.....	.....	117 1 33·9	
		12 16 47·5	.....	.....	.....	117 3 24·3	
Liége	„ 24	2 50 44·1	30 17·45	.....	104 17 45		
		4 37 29·5	.....	.....	.....	163 20 59·9	
		4 44 51·5	.....	.....	.....	163 20 8·0	129 26 20
Aix-la-Chapelle	„ 26	3 56 18·9	30 25·94	.....	24 36 45		
		4 7 31·5	.....	.....	27 5 0		
		4 15 37·9	.....	.....	28 50 0		
		4 50 45	.....	.....	.....	219 25 3·5	
		4 58 15	.....	.....	.....	219 23 26·2	
		5 6 30	.....	.....	.....	219 21 16·4	101 26 30
Spa	„ 29	11 16 25·3 A.M.	30 38·67	.....	66 1 30		
		11 21 46·4	.....	.....	67 56 45		
		11 27 46·3	.....	.....	70 6 30		
		11 49 30	.....	.....	.....	192 44 23	
		11 55 0	.....	.....	.....	192 43 57	124 20 45
Arlon	„ 31	2 14 19·0 P.M.	30 47·16	.....	91 14 45		
		2 19 41·5	.....	.....	92 48 30		
		2 25 4·3	.....	.....	94 20 30		
		3 9 30	.....	.....	.....	230 54 23·6	
		3 16 30	.....	.....	.....	230 51 47·8	
		3 22 30	.....	.....	.....	230 50 17·0	199 45 15
Namur	Sept. 2	11 37 16·1 A.M.	30 55·65	.....	60 42 30		
		11 43 55·5	.....	.....	63 6 30		
		11 48 42·1	.....	.....	64 50 30		
		11 7 51	.....	.....	.....	235 51 13	
		11 12 0	.....	.....	.....	235 50 54	180 28 25
Mons	„ 4	4 12 5·8 P.M.	31 4·14	.....	187 55 15		
		4 17 55·6	.....	.....	189 11 30		
		4 24 23·1	.....	.....	190 34 30		
		4 31 10·8	.....	.....	192 0 0		
		4 56 0	.....	.....	.....	268 58 4·8	
		5 1 0	.....	.....	.....	268 56 53·4	
		5 6 0	.....	.....	.....	268 56 27·5	168 31 40

TABLE XIV. (continued).

Station.	Date.	Chronometer.	Error at Noon.	Daily Rate.	Azimuthal distance of sun from mark.	Azimuthal reading of magnet.	Azimuthal reading of mark.
	1871.	h m s	m s		° ′ ″		
Tournay	Sept. 6	2 41 11·3 P.M.	+31 12·63	.....	98 36 0		
		2 46 41·8	.....	.....	100 5 0		
		2 52 1·6	.....	.....	101 30 30		
		2 57 20·1	.....	.....	102 54 45		
		3 22 0	.....	.....	.....	125 17 57·5	
		3 28 0	.....	.....	.....	125 18 16·9	91 37 15
Courtray	,, 7	11 13 38·6 A.M.	31 16·88	.....	96 9 45		
		11 18 59·0	.....	.....	97 56 30		
		11 25 2·8	.....	.....	99 59 0		
		11 30 57·5	.....	.....	102 0 30		
		12 3 30 P.M.	.....	.....	.....	253 23 21·0	
		12 9 0	.....	.....	.....	253 23 1·5	153 6 5
Ghent	,, 9	11 31 1·4 A.M.	31 25·37	.....	28 50 30		
		11 42 56·0	.....	.....	24 46 30		
		11 51 58·1	.....	.....	21 39 30		
		12 9 0 P.M.	.....	.....	.....	270 2 22·3	
		12 13 0	.....	.....	.....	270 3 20·7	122 5 30
		1 27 0	.....	.....	.....	269 53 23·0	
		1 31 30	.....	.....	.....	269 52 44·0	122 6 30
Ostend	,, 12	8 58 23·4 A.M.	31 38·10	.....	13 55 52		
		9 3 53·1	.....	.....	15 14 22		
		9 10 5·6	.....	.....	16 45 22		
		9 15 59·0	.....	.....	18 11 22		
		9 58 0	.....	.....	.....	112 17 20·9	
		10 2 30	.....	.....	.....	112 16 42·0	237 37 15
Bruges	,, 14	3 8 6·5 P.M.	31 46·69	.....	19 17 45		
		3 17 18·4	.....	.....	21 34 0		
		3 26 49·9	.....	.....	23 52 0		
		4 0 30	.....	.....	.....	186 1 46·6	
		4 5 30	.....	.....	.....	186 1 40·1	237 12 5
Tronchiennes	,, 16	8 55 36·4 A.M.	31 55·08	.....	58 44 30		
		9 1 37·8	.....	.....	60 10 15		
		9 6 41·1	.....	.....	61 23 30		
		9 10 51·1	.....	.....	62 24 0		
		9 50 30	.....	.....	.....	192 31 21·4	
		9 57 0	.....	.....	.....	192 30 24·2	
		10 1 0	.....	.....	.....	192 31 42·1	94 1 10
Alost	,, 19	9 12 2·1	32 7·81	.....	24 10 30		
		9 17 14·8	.....	.....	22 52 45		
		10 33 0	.....	.....	.....	251 28 6·7	
		10 38 30	.....	.....	.....	251 28 52·2	
		10 44 0	.....	.....	.....	251 29 24·6	240 31 35
Brussels, 131 rue Royale	,, 20	2 12 39·5 P.M.	32 12·06	.....	17 24 0		
		2 21 46·5	.....	.....	14 54 15		
		2 57 30	.....	.....	.....	188 13 38·6	
		3 3 0	.....	.....	.....	188 13 38·6	261 28 50
Brussels Observatory	,, 22	9 55 45·8 A.M.	32 20·55	.....	32 42 45		
		10 0 56 0	.....	.....	31 18 15		
		10 51 30	.....	.....	.....	181 57 24·2	
		10 58 30	.....	.....	.....	181 55 14·4	192 25 0
	,, 22	11 13 44·4	.....	.....	10 17 45		
		11 19 11·5	.....	.....	8 35 15		
		11 49 30	.....	.....	.....	181 42 30·6	
		11 54 0	.....	.....	.....	181 40 46·8	192 47 37·5

To complete the determination of the Declination at the different stations, it is necessary to compute the azimuth of the sun at the times of observation. The mean result for each station is contained in the following Table, along with the Declination corrected for Scale-reading, as well as for Daily Range, and for any irregular perturbation that may have occurred at the moment of observation. Fortunately the magnet was always very quiet during the hours of observation, and hence the greater part of the correction in each case is due to Daily Range, which can be estimated more correctly than could the effect of any great disturbance. In order to calculate this correction, I have been obliged to make

use of the magnetograms of Stonyhurst Observatory, as no continuous records have as yet been obtained in Belgium of the magnetic elements. The differences between the ordinates of the curve at the absolute times of observation, and the mean ordinate for July, August, September, and October, multiplied into 28′ 38″·9, the scale-coefficient of the Declination Magnetograph, give a close approximation to the correction required for reducing the results to September 1st for Stonyhurst. To apply these to observations made in Belgium I have introduced the factor 0·69, as I find from the mean values obtained at the Brussels Observatory for 9 A.M., noon, 3 P.M., and 9 P.M., compared with those deduced at Stonyhurst for the same hours, that the movements are in the ratio of 0·69 to 1. This will of course give only a first approximation, but the data will scarcely admit of greater exactness.

TABLE XV.

Station.	Azimuth of Sun.	Observed W. Declination.	Declination corrected for Range and Disturbance.
	° ′ ″	° ′ ″	° ′ ″
Antwerp	48 9 41·2	17 30 41·7	17 33 16
		17 30 22·2	17 31 33
Brussels Observatory	.....	18 3 49·5	17 59 52
		18 4 46·0	18 1 0
Brussels, 131 rue Royale	76 2 47·7	17 8 0·4	17 12 45
		17 8 0·4	17 12 57
Louvain	47 49 41·1	16 46 15·3	16 50 12
		16 47 27·1	16 51 48
		16 49 49·9	16 55 10
Turnhout	22 4 5·1	17 13 13·7	17 5 32
		17 11 23·3	17 3 5
Liége	54 6 53·1	16 16 12·0	16 16 0
		16 17 3·9	16 17 16
Aix-la-Chapelle	72 21 10·3	16 30 51·2	16 28 29
		16 32 28·5	16 30 19
		16 34 38·3	16 32 39
Spa	17 5 47·9	16 43 44·9	16 39 59
		16 44 10·9	16 40 25
Arlon	45 8 52·8	16 29 35·4	16 23 51
		16 32 11·2	16 26 51
		16 33 42·0	16 28 34
Namur	10 10 14·0	17 40 36·0	17 34 52
		17 40 55·0	17 34 59
Mons	72 7 29·5	17 21 24·7	17 13 43
		17 22 36·1	17 15 41
		17 23 2·0	17 16 42
Tournay	49 15 37·1	17 50 14·2	17 43 43
		17 49 54·8	17 43 59
Courtray	18 47 53·8	17 54 32·8	17 47 14
		17 54 52·3	17 48 9
Ghent	11 1 26·5	17 59 4·3	17 54 8
		17 58 5·9	17 52 46
		17 59 3·5	17 49 58
		17 59 32·5	17 50 4
Ostend	56 45 19·0	18 6 57·6	18 7 34
		18 7 36·5	18 8 35
Bruges	54 43 41·9	18 1 11·5	17 58 25
		18 1 18·0	17 58 32
Tronchiennes	55 47 49·1	17 55 41·5	17 55 53
		17 56 38·6	17 53 53
		17 55 20·7	17 52 47
Alost	51 54 1·1	17 25 51·8	17 23 53
		17 25 6·4	17 22 44
		17 24 34·0	17 22 35
Brussels, 131 rue Royale	39 40 30·1	17 25 33·8	17 23 0
		17 25 33·8	17 23 12
Brussels Observatory	39 25 24·6	17 52 30·3	17 54 5
		17 54 40·1	17 56 15
„ „	16 25 10·1	18 3 46·9	18 3 47
		18 5 30·8	18 5 31

The figures in column 3, which are obtained directly from the unifilar, furnish the first members of the equations, whose solution is

$$x = \quad 0{\cdot}0119696,$$
$$y = -\ 0{\cdot}0012255,$$
$$\mathrm{D} = \ 17^{\circ}{\cdot}3881.$$

Thus the position of the isogonics will be N. 5° 50′ 46″·2 E. to S. 5° 50′ 46″·2 W., and the distance between lines, differing by 30′, 41·56 miles.

If, on the other hand, we use the corrected values of column 4 in the formation of our equations, the solution becomes

$$x = \quad 0{\cdot}0115492,$$
$$y = -0{\cdot}0022202,$$
$$\mathrm{D} = \ 17^{\circ}{\cdot}3368;$$

and then the isogonics lie at an angle of 10° 52′ 54″·7 to the astronomical meridian, and their distance is 42·51 miles. The corrections have therefore altered very considerably the direction of the isogonics without affecting much their distance apart. We may judge from the following Table how far these corrections have diminished the probable error in the results.

TABLE XVI.

Station.	Uncorrected Declination.		Error.	Corrected Declination.		Error.
	Observed.	Computed.		Observed.	Computed.	
Aix-la-Chapelle.....	0·544	0·483	+0·061	0·508	0·457	+0·051
Alost	1·420	1·567	−0·147	1·384	1·516	−0·132
Antwerp.....	1·509	1·402	+0·107	1·540	1·377	+0·163
Arlon	0·530	0·528	+0·002	0·440	0·424	+0·016
Bruges	2·021	2·014	+0·007	1·975	1·967	+0·008
Courtray	1·912	1·954	−0·042	1·795	1·880	−0·085
Ghent.....	1·983	1·740	+0·243	1·862	1·691	+0·171
Liége	0·277	0·732	−0·445	0·277	0·690	−0·413
Louvain.....	0·797	1·220	−0·423	0·873	1·178	−0·305
Mons	1·373	1·576	−0·203	1·256	1·490	−0·234
Namur	1·677	1·100	+0·577	1·582	1·032	+0·550
Ostend	2·121	2·173	−0·052	2·135	2·120	+0·015
Spa.....	0·733	0·577	+0·156	0·670	0·528	+0·142
Tournay.....	1·835	1·882	−0·047	1·731	1·796	−0·065
Tronchiennes.....	1·932	1·773	+0·159	1·903	1·723	+0·180
Turnhout	1·205	1·144	+0·061	1·072	1·135	−0·063

The probable errors at any station will therefore be $\pm 0{\cdot}16585$ for the uncorrected and $\pm 0{\cdot}15234$ for the corrected values, whilst those of the mean are respectively $\pm 0{\cdot}04146$ and $\pm 0{\cdot}03809$.

The direction of the isogonics, when the corrected numbers are employed, approaches nearer to that found for France than when the uncorrected observations are used, but it is still considerably in defect. There is scarcely any difference between the closeness of the lines in Belgium and in the West of France.

For the calculation of the secular variation of the Declination, the only available observations made out of Brussels are those of LAMONT in 1858, since the two observations of last century mentioned at the beginning of this paper would not help us to

ascertain the actual yearly change of this element. Dr. LAMONT observed at Aix-la-Chapelle, Ghent, and Mechlin; but as I did not take the Declination at Mechlin, the comparison is confined to two stations.

TABLE XVII.

Station.	nation, Jan. 1, 1858.	Declination, Sept. 1, 1871.	Secular variation.
Aix-la-Chapelle	18·243	16·544	−0·124
Ghent.....	19·560	17·983	−0·115
	Mean for epoch 1864·8 ...		−0·1195

If we use the corrected values for September 1, 1871, the secular variation becomes −0·1255. LAMONT gives −0·1267 for 1858.

From the long series of observations made at the Royal Observatory of Brussels by MM. A. and E. QUETELET, from 1828 to 1871, I find the following values of the secular variation:—

Epoch 1838·75 . . . . −0·0896
„ 1849·5 . . . . −0·1065
„ 1860·25 . . . . −0·1234.

The yearly acceleration is therefore constant, and = −0·00158.

The observations at Brussels give very unsatisfactory results, when we regard the absolute values, and not merely the yearly change at a permanent unaltered station. In 1858 LAMONT found a difference of 28′ between the Declination at the observatory and that at a station not far distant; E. QUETELET confirmed this result the same year, the difference being 30′; and now, at positions so close together as the observatory and 131 rue Royale, I find a still greater mean difference. The Declination observations made at Brussels during this survey were as follows:—

	Uncorrected values.	Corrected values.
Computed results	17°·3881	17°·3368
Observatory, August	18·0716	18·0072
„ September . . .	17·8931	17·9195
„ „ . . .	18·0775	18·0775
„ Error of mean .	+ 0·6260	+ 0·6646
131 rue Royale, August . . .	17·1334	17·2125
„ September . .	17·4261	17·3850
„ Error of mean	− 0·1083	− 0·0380

The station near the observatory, though apparently not free from disturbing influences, gives from the corrected values a result almost identical with the computed quantity, since it is within the range of its probable error, whilst the result for the observatory itself is more than half a degree in excess. This difference of Declination,

combined with the fact that the errors of the observed Dip at both stations are positive and their errors of H. F. both negative, might justify the assumption that the disturbing cause is situated at no great distance from the observatory, and probably at some depth and to the W. of the N. meridian. The probable errors of the observed Dip and H. F. at the observatory were not very large, being respectively $+7'\ 15''$ and $-0{\cdot}0070$.

It may be of advantage, in particular for the discussion of the errors of the Total Force, to present here in a tabular form a geological description of the stations of observation. The data in this Table are taken from the excellent map of M. André Dumont, á copy of which was kindly presented to me for this purpose by his son.

Table XVIII.

Station.	Geological formation.
Aix-la-Chapelle	Terrain crétacé, système Aachenien. E.S.E. houille.
Alost	Terrain tertiaire, eocène, glauconie.
Antwerp	„ „ pliocène, système Scaldisien.
Arlon	„ jurassique, système liasique.
Bruges	„ tertiaire, miocène, argile verte et sable marin.
	„ „ eocène, glauconie supérieure.
Brussels	„ „ „ glauconie; sable et grès de Beauchamp.
Courtray	„ „ „ glauconie moyenne.
Ghent	„ „ „ glauconie supérieure.
Liége	E., W., N. houille. S. terrain anthraxifère, système Eifelien, quartzoschisteux.
Lierre	Terrain tertiaire, pliocène, système Diestien.
Louvain	„ „ N. miocène, argile verte et sable marin; S. glauconie supérieure; E., W. pliocène, système Diestien.
Mechlin	„ „ miocène, argile verte, sable marin, et grès de Fontainebleau.
Mons	E., N.E., S.W. houille. S. terrain tertiaire, eocène, glauconie moyenne.
Namur	Terrain anthraxifère. N. système Condrusien, calcareux; S. houille.
Ostend	Alluvions.
Spa	Terrain Ardennais. N.W. terrain Rhénan, système Gedinnien.
Tournay	„ tertiaire, eocène, glauconie. S.E. terrain anthraxifère, système Condrusien, calcareux.
Tronchiennes	Terrain tertiaire, eocène, glauconie supérieure.
Turnhout	„ „ miocène, système Bolderien.
Verviers	„ Ardennais, système Salmien; et terrain Rhénan, système Gedinnien.

The three maps annexed to this paper (Plates XIX.–XXI.) show the general direction of the lines of equal Dip, H. F., and Declination. The broken lines for 1871 are calculated on the supposition of the isoclinals, isodynamics, and isogonics being approximately straight, and the observed mean values are attached to each station in order to show how nearly these straight lines represent the actual curves.

This has also been made more evident by introducing the curves of equal values, which are represented by continuous lines. The method adopted in drawing these lines is shown in the map of the isodynamics; and the shaded portions of the same map indicate the position and extent of the coal-beds of Belgium, which lie, for the most part, along the banks of the Meuse.

The greatness of the accidental errors, as well as the narrow limits of the tract of country under consideration, renders it very difficult to trace, with any great degree of accuracy, the probable curvature of the actual lines of equal Dip, Declination, and Intensity. But bearing in mind that in all cases the errors arising from defects of station or of observation mask to a great extent the real nature of these curves, we may still clearly

perceive two apparent centres of disturbing action,—the one situated in the N.W. centre, and manifested by a great increase of the Dip and a diminution of the Horizontal Force, and the other, more extended and less intense, stretching along the Coal-measures, and giving evidence of its existence by a diminution of the Dip and an increase of the Horizontal component of the Intensity.

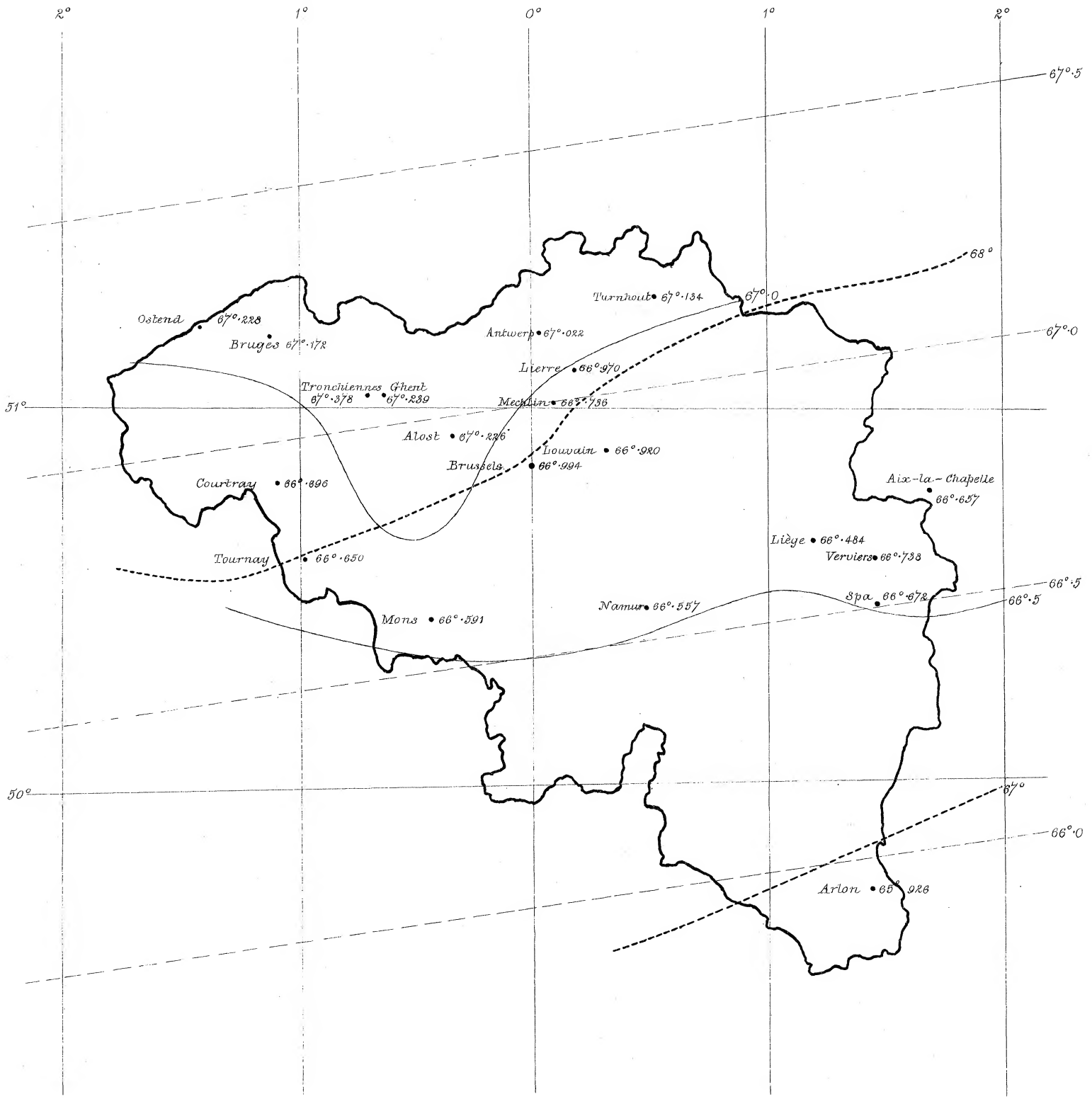
The dotted lines are an enlarged reproduction of the curves on LAMONT'S maps; and from being enlarged they will naturally give a somewhat exaggerated idea of the lesser inequalities, though the general curvature be perfectly correct.

I will now conclude this paper with a list of the magnetic elements at the several stations, the observations being all reduced to the common epoch, January 1st, 1872. In this reduction I have adopted the yearly changes determined by the survey, viz. −0·0573, +0·00542, −0·01155, and −0·1255 respectively for the Dip, H. F., T. F., and the corrected Declination.

TABLE XIX.

Station.	Declination.	Dip.	Horizontal Force.	Total Force.
Aix-la-Chapelle	16°·464	66°·637	4·0064	10·1025
Alost	17·349	67·210	3·9518	10·2016
Antwerp	17·489	66·999	3·9296	10·0559
Arlon	16·398	65·907	4·1175	10·0857
Bruges	17·938	67·155	3·8950	10·0321
Brussels	17·959	66·975	3·9613	10·1271
Courtray	17·756	66·678	4·0028	10·1103
Ghent	17·823	67·221	3·9197	10·1232
Liége	16·233	66·464	4·0145	10·0522
Lierre	.....	66·948	.....	.....
Louvain	16·824	66·898	3·9565	10·0828
Mechlin	.....	66·714	.....	.....
Mons	17·216	66·573	4·0065	10·0767
Namur	17·541	66·538	3·9941	10·0311
Ostend	18·097	67·211	3·9152	10·1077
Spa	16·627	66·653	4·0239	10·1531
Tournay	17·691	66·632	3·9975	10·0776
Tronchiennes	17·867	67·361	3·9032	10·1397
Turnhout	17·025	67·113	3·9542	10·1665
Verviers	.....	66·718	.....	.....

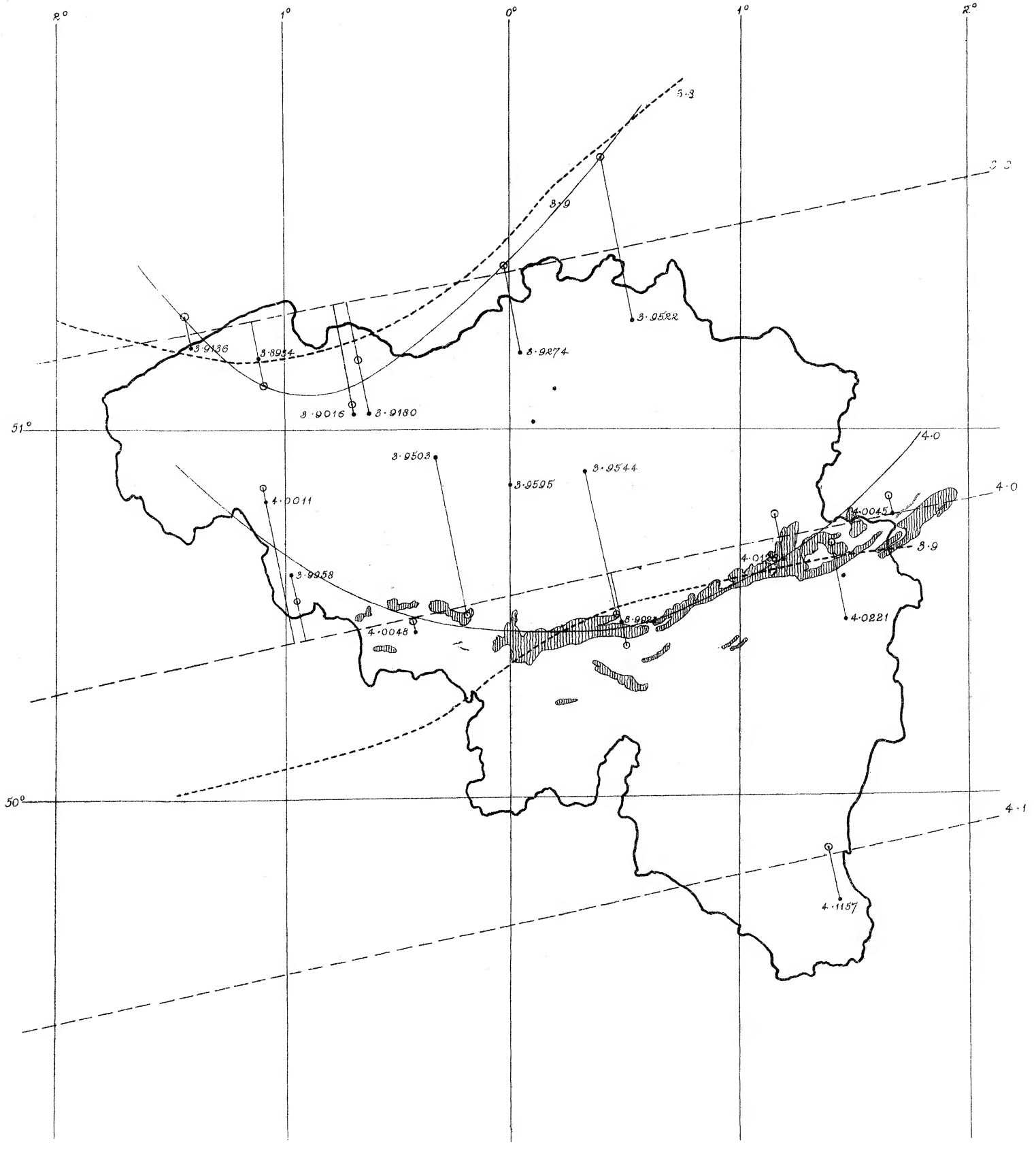
Magnetic Dip.



Isoclinals Epoch 1871 ———————

" " 1849 - - - - - - - - - -

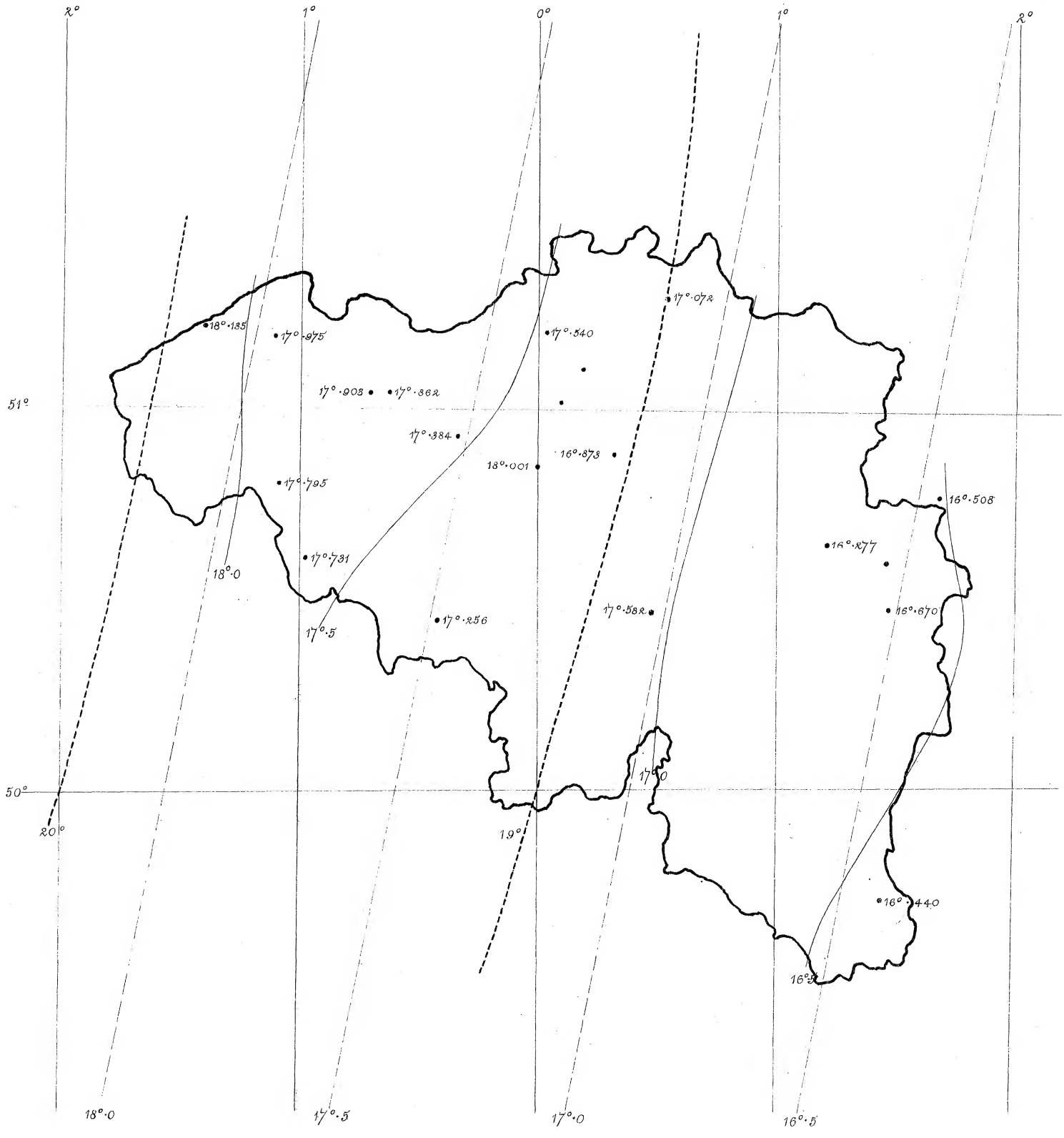
Magnetic Intensity.



Lines of equal Horizontal Force. Epoch 1850 ---------- ---

" " 1871 — — — — — — —

Magnetic Declination.



Isogonics. Epoch 1848 ----------

" " 1871 - - - - - - - - - -